WHY THE MOVIES MOVE

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OVER nine tenths of us are now confirmed movie goers. The remaining one tenth will without doubt soon be enthusiastic converts to the silver screen, while those few who do not attend or are not regular in their movie habits either do not know what they are missing or else it is physically impossible for them to attend.

Among the millions who are weekly movie goers there are at the most only a few hundred who understand why the pictures seem to move. Every one knows that countless thousands of pictures are flashed on the screen in rapid succession and in such wise as to produce the effect of motion. This is about the limit of common knowledge regarding why the movies move. But after you have read and understood and remembered this account of the why of the movies you may count yourself among the few hundred who understand how the effect of motion is produced.

It is easy to take things for granted without striving for an understanding of them. This is the great American characteristic. We are too easily content with a half truth or with a superficial explanation.

As adults we seem largely to have lost the thoroughgoing inquisitiveness which characterizes certain periods of childhood. Then we asked what, why, where, when, how, and ended up with why is it that way. Now as adults only a single, cursory question is asked and, lest we betray ignorance or slowness to comprehend, we let an "Oh, yes! That is so" take the place of the series of follow-up questions which should be put to clarify and explain things.

The best intellectual tonic we can experience as adults is a reversion, as it were, to this inquisitiveness of our childhood which forced us to stick to a problem until it was satisfactorily and genuinely solved or understood.

When one really once understands some of the applications of science in providing the comforts and recreations for his daily life, one comes into a realization of the wonderful progress of science with a clearness and a force which can be obtained in no other way. And at the same time one has his appreciations of the newer conveniences and luxuries vastly deepened.

So pause from time to time as you read this article and reflect upon the marvelous complexity and achievement of the daily movie. And, by the same token, make the attempt to spread this curiosity and appreciation out into the numerous phases of applied science which touch upon your life from the electric grill in the morning to the violet ray bath at night.

The story of the development of the motion picture industry is a fascinating bit of history in financial organization and international trade competition. Why the movies move is as fascinating a morsel from the recent history of applied science and the progress of mechanics.

The present excellence of clearness, freedom from flicker, and the illusion of motion in the movie are due to the ingenious application and capitalization of certain facts primarily from the field of psychology. It will be necessary to review these interesting discoveries in order to establish a basis for an understanding of why these pictures, which are really intermittent, motionless and flat, nevertheless appear to be continuous in motion, and to possess depth,

There are three questions for us to answer regarding the motion picture. First: Why is it that the pictures seem continuous when as a matter of fact the screen is in almost total darkness sixteen times a second and in partial darkness sixteen or more additional times each second? Then the second question is: Why do we get the impression of motion from these pictures which in reality are absolutely motionless? And, third: Why do the pictures have the appearance of depth when in reality they extend only to the right and left, and up and down and do not possess any objective third dimension or depth?

It is to the eye that the motion picture makes its first appeal. And since it is through vision that the apparent motion is perceived it will be necessary for us to take up first of all some phases of the structure and function of the eye as a basis for our understanding of the movies.

I

The human eye is a miniature camera, capable of a large variety adjustments. The eye is wonderfully responsive, and automatically so, to the slightest change in light, color, or position. But it is not without its defects and shortcomings even in so-called normal eyes. It is by the capitalization of some of these peculiarities, which almost amount to defects, that the movies are made possible.

Just behind the pupil of the eye is a small crystalline lens that automatically adjusts itself to different distances and conditions

of vision. The eye thus differs from all other cameras in being self-focusing.

No light can enter the human eye except through the lens, since the remainder of the eye forms a light-proof box. The rays of light which pass through this lens into the eye are focused upon the inner surface of the eyeball. This is covered with a layer of highly specialized nervous substance which is acted upon by changes caused by the light. This specialized layer is called the retina and corresponds to the sensitive film or plate in the ordinary camera.

In the camera the momentary exposure of light causes a chemical change on the sensitized surface of the film. But before the picture can be brought into view further chemical changes must be effected by the photographer in the processes of development and fixation.

Not so with this marvelous human camera. Although vision is essentially momentary in character, due to the continual movement of the eye itself, exposure follows exposure and chemical change follows upon chemical change. There is not time to call in the photographer to develop and fix the pictures after each exposure. Indeed, there is no need.

Nature has provided the human camera with a chemical substance sensitive to light which automatically renews itself. This material is called rhodopsin, or visual purple, from its appearance in freshly dissected eyes. This visual purple permeates the entire retinal structure and is probably the keystone to vision.

The development and fixation in the human camera takes place mainly outside the eye. This occurs principally in the brain, to which the eyes are connected by a direct nervous pathway. The retina of the eye is the outpost of the brain, but the nervous material in the retina is not affected directly by the rays of light focused upon it by the crystalline lens.

There is an interesting bit of experimental evidence which demonstrates this beyond doubt. Retinas which have been washed free from all chemicals which might permeate the network of nervous fibers have been used for experimentation. It has been found that in order to stimulate this purely nervous structure of the eye directly the light must be so strong as practically to destroy these nervous elements. And still it is a matter for common observation that we can see, that is, our retinas are stimulated by lights of weak intensity.

The only explanation is the one already suggested. The light acts first upon some photo-chemical substance which bathes the retina, and the changed chemical composition which the light waves bring about stimulates the nervous parts of the retina.

Just what this substance is remains an open question. There is some evidence to indicate that it is not the visual purple. For example, Kühne found that through continued exposure to light the visual purple in a frog's eye was completely bleached. Still the frog reacted to light and changes in light in a practically normal manner after this thorough bleaching had taken place.

The visual purple is probably the chemical medium for the adaptation of the eye to light or dark illumination. In passing from the open air into the darkened motion picture theater it takes some time for one's eyes to "get used to the dark." This is technically known as adaptation, and its chemical basis in the eye is the visual purple. This same substance may have a prominent part in the general vision, or another still undiscovered chemical substance may be the basis for vision.

At any rate, vision is primarily photo-chemical. Without the intervention of some photo-chemical material the energy which we call light has no ordinary effect upon the eye.

The light which is focused upon the retina by the lens alters the arrangement of the molecules in the photo-chemical substance. This changed chemical condition stimulates the nervous endings in the retina and these carry their impulses to the brain where they are developed (perceived) and fixed (remembered).

This photo-chemical structure in the retina of the eye is not only the keystone in ordinary vision; it is through some of its properties that the motion picture is made possible. We will now turn our attention to those properties of this substance upon which the motion picture depends.

Every material mechanism exhibits a property which physicists term *inertia*. By virtue of this property matter tends to remain in a state of uniform inactivity or uniform motion unless acted upon by some external force. One finds many illustrations of this in every-day life. Let us take an example from automobiling. If it were not for the inital inertia to be overcome there would be no need for a shift of gears from low through intermediate into high in order to get the machine under way. The initial sluggishness or inertia of the machine has to be overcome before the automobile can be propelled at its usual speed. And when once under way it will continue to move when the power is shut off; it is necessary to apply the brakes in order to bring the machine to a halt. The effects of inertia are met with both in starting and stopping an automobile.

But what has this matter of inertia to do with motion pictures? A great deal, indeed. An example or two will suffice to demonstrate the inertia which is present in the eye.

It is only to be expected that we find inertia in the organ of vision since we have found the eye to be mecano-chemical in operation. Inertia is found in the eye as in any other material mechanism.

Inital inertia—the inertia to be overcome in starting—manifests itself in the retina in what is known as the latent time. A few hundredths of a second elapse between the moment a beam of light falls upon the retina and the beginning of the resulting nervous impulse in the retina. This time is consumed in overcoming the molecular inertia of the photo-chemical stimulating medium.

In the case of the automobile the inital inertia can be overcome quickest by the highest powered car. In the case of the retinal lag—the inital inertia—the latent period also decreases with an increase in the intensity of the light.

This initial lag in the retina is difficult to demonstrate except with the aid of intricate laboratory apparatus. The retinal persistence, or what corresponds to the inertia of stopping in the automobile, however, is easily demonstrated. In a recent issue of *The Journal of Experimental Psychology* I described a new apparatus for the study of visual after-images. A rough and ready demonstration apparatus along the same lines can easily be improvised.

Stand in a dark room with the eyes about two feet from a round, gas-filled, clear glass electric bulb. Remain in the dark for about five minutes so the visual purple of the eye may become adapted to the dark. Then switch the light on for just an instant, watching the bright yellow filament closely.

What is seen after the light is switched off? Although all stimulation is removed an identical image of the red-hot filament remains for a considerable length of time and is seen as if it were projected out in space in front of the eyes. Move your eyes and you will find this image follows the movements of the eye, showing that it is not imaginary but really in the retina. This phenomenon is due to the inertia and is termed retinal persistence.

This retinal persistence is always present and the experimental procedure simply accentuated it in a manner to make it readily observable. All ordinary visual images persist for about three thousandths of a second at the full intensity of the original stimulus, even after it has ceased to act upon the eye. Intense stimulation, such as the gas-filled bulb and the movie screen give, or long continued stimulation, causes the terminal inertia to remain for a much longer time.

This identical image which remained after the stimulus was withdrawn is known as the positive after-image. After this posi-

tive after-image fades away it is followed by another which is the exact reverse in coloring and hence called the negative after-image.

If you will try the light bulb experiment again you will observe, after the positive after-image has disappeared, a line identical in form and position with the red hot filament, but opposite in coloration. This is the negative after-image. Under these conditions it is usually so dark as to be easily seen even in the already dark field of the eye. Usually this dark image is seen fringed with a narrow light greenish-yellow band. When colors are used to cause these negative after-images, they always have the complementary coloration. For example, the negative after-image of a blue square of paper is yellow, the negative after-image of a green paper is red.

Negative after-images have little to do with the movies except in colored projection. They are simply mentioned here that some adequate comprehension may be given of the great complexity of the retinal inertia as it is manifest in visual persistence. It is also largely through a study of these after-images that the nature of the photo-chemical properties of the eye was first brought under observation.

We are now near an answer to the first problem which we set up regarding the movies.

As almost universally projected at present, sixteen separate pictures are flashed on to the screen within one second. In the earlier machines, as in Edison's kinetoscope, the film was passed steadily. But with the bright illumination and large pictures now in use the picture has to be still while on the screen. Otherwise nothing but one great, big, rectangular blurr would be seen.

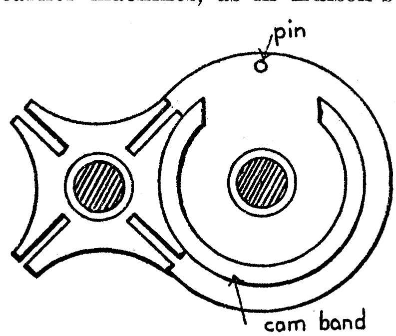


Figure 1. Maltese Cross Movement for jerking the pictures before the lens one at a time. The pin wheel revolves steadily, the cam band holding the Maltese cross firmly in position until the pin enters the slot; then the cross is turned 90 degrees. The axle that carries the cross also carries a sprocket which meshes with the openings in the film and jerks it down picture by picture as the pin pulls the cross around one-quarter of a turn.

In order to accomplish this still projection of the individual pictures to produce the motion picture each picture is jerked before the lens one at a time. A "Maltese Cross" movement, such as is used for the escapement in Swiss watches, jerks the film down picture by picture in the modern projector. That the film may be held rock steady after the intermittent "Maltese Cross" movement has pulled it down it is passed through a tension gate which holds the film tightly at all times.

The clearness, freedom from flicker and illusion of motion are all furthered by the addition of the shutter. This revolves in the path of light of the projector and is timed so that the large blade of the shutter completely cuts off the light while the intermittent movement is pulling down the next picture. The film is thus not seen while in movement but only after it has come to rest.

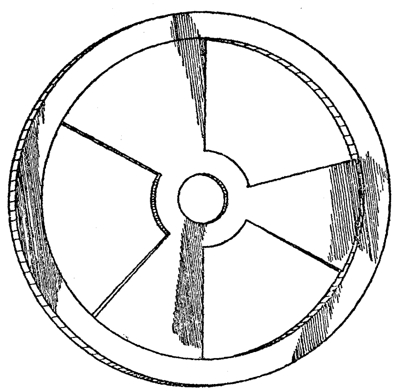


Figure 2. Shutter which revolves in front of the lens, interrupting the path of light. The large blade cuts off the light while the film is being jerked down; the smaller blades are the "flicker" blades.

This shutter cuts the light completely off from the screen while each picture is being jerked into place. Sixteen times in each second the screen is in complete darkness. In addition to this there is a "flicker" blade or two in the shutter which passes in front of the picture and partially shuts off the light while it is being projected on to the screen. The purpose of this "flicker" blade will be mentioned and explained directly.

In view of the findings of our brief survey of the properties of the eye and especially the manifestations of the retinal inertia it will now be possible for an adequate explanation to be given for the apparent continuity of the movie which is actually intermittent.

Retinal persistence is the key. Although the light thrown on the screen is interrupted thirty-two or more times each second a positive after-image of each picture remains until the next picture is projected in full intensity on the screen. The actual period of darkness on the retina is bridged over by the retinal persistence. This is what gives apparent continuity to the motion picture.

The shutter is a significant factor in giving the pictures clearness by shutting off the movement of the pictures as they are jerked into place. The absence of flicker, however, is also largely due to two other factors, namely, the intensity of illumination used and the "flicker" blade of the shutter.

The duration of the retinal lag and persistence varies according to the intensity of the stimulus, which, in this case, is the brightness of the light. As the intensity of the illumination increases, the period of lag decreases, while the period of persistence increases. Thus with the strong illumination which the modern electric arc furnishes, the appearance of continuity is furthered and the intervals of actual darkness are covered by brighter positive after-images than would otherwise be possible.

If the same films and projection apparatus that are now used to project the motion picture were combined with the old acetylene light source there would be a reappearance of the flicker due to the lengthened lag and shortened persistence. It is therefore apparent that the bright illumination not only gives clearness and brightness, but also aids in the steadiness, continuity and the elimination of the flicker.

Now to take up the part of the "flicker" blade. Upon first thought it would seem disastrous to introduce any more flicker than absolutely necessary in order to cover each jerk of the film. Obviously such is not the case. The reason for this will be made clear by reference to some laboratory experiments.

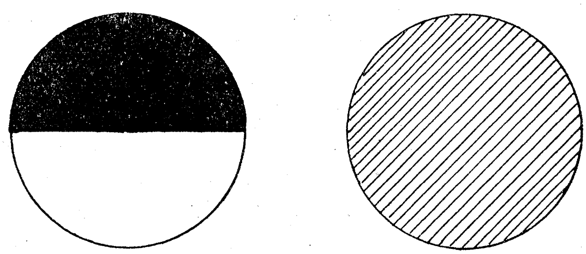


Figure 3. When a disc composed of two sectors such as is shown at the left is rotated with sufficient speed the colors fuse and produce an intermediate grey such as diagrammed. Before the proper speed of rotation is reached flicker is present rather than fusion.

When a disc composed of two equal black and white sectors is rotated by an electric motor whose speed is under control three series of phenomena are observed as the speed is increased. With only a few revolutions each second it is still possible for the two sectors to be clearly seen. As the speed is gradually increased, however, there seems to be a slight admixture of color with the black and white sectors which now appear to be pulsating slightly. These colors are known as Fechner's colors, after the pioneer in psychological investigation who first observed them. They are due to peculiarities in the photo-chemical materials in the retina.

The second phenomenon occurs when the speed of rotation is still further increased. This is known as flicker. The even, pulsating, rhythmical alternation of the black and white observed with the slower speed is replaced by an unsteady, wavering flicker which produces a great strain on the eyes. This experimental flicker is similar to the flicker which accompanied the earlier attempts to project motion pictures.

Increasing the speed of rotation still more causes this flicker to become more and more steady until at last a certain point is reached at which fusion is produced. When this is reached, the unsteady, fluctuating flicker is displaced by a blend of black and white which appears as an even, smooth, grey. In contrast to the

strain of the flicker, this fusion of the two colors is pleasing to look upon and resting to the eyes.

Stated in terms of the retinal inertia, this fusion results when the stimuli impinge upon the retina with such rapidity that the initial lag of the one blends or fuses with the residual persistence of the other.

Without the "flicker" blade on the shutter of motion-picture projector the intervals of light and darkness are so far separated that only the flicker phenomenon is produced. If the speed of the projector were increased so as to overcome this flicker it would result in each picture being shown for so short an interval that there would scarcely be time for each one to overcome the inital lag of the retina. With the addition of this "flicker" blade, however, the number of interruptions is doubled without increasing the speed and thus fusion is made to replace flicker.

It will be recalled that in the experiment just described the resulting fusion was neither white nor black but an intermediate grey. This lessening of intensity by the interruptions follows a definite course which is predictable by Talbot's law.

In modern motion picture production the overcoming of the flicker has also resulted in lessening to a considerable extent the apparent intensity of illumination in the projected pictures. But through the aid of the intense electric arc and the mirror screens the lighting used is so high powered that the resulting fusion is still bright and clear.

II

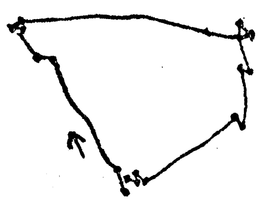
The illusion of motion in the photo-play can not be explained in the positive way in which we accounted for the appearance of continuity and the clearness and freedom from flicker. There is still some controversy among psychologists regarding the perception of visual motion in ordinary life. The problem is gradually becoming settled, but in fairness we must review the chief accounts which are current. Then we can not only decide which one best explains the visual perception of motion in the motion picture but we can also see what the motion picture can contribute in a constructive way to these theories.

There are several of these classical theories which must be mentioned in this connection. Eye movements have been used for a long time to account for the perception of motion by the eye. This theory holds that the eye follows moving objects and that we get the impression of motion from the strain and tension on the six muscles that move each eye. There are two major objections, however, which seem to render this theory untenable in its usual form.

In the first place, the more recent experimental work indicates that after all our judgment of the movements of the eye muscles is very inaccurate. If our knowledge of these movements were used as a basis for an interpretation of motion in the external world such motions would be grossly misinterpreted to say the least. A second fatal bit of evidence against the theory is that in addition to our inaccurate knowledge of the eye movements, the movements themselves do not conform to the external motions or objects with any degree of accuracy. This is plainly shown in the illustration of the movements of an eye in following the outline of a circle.

We must look, then, to the nervous and retinal elements of the eye rather than to its musculature for an explanation of the perception of visible motion.

The phenomena of retinal streaming has been used by some psychologists as a partial explanation of the perception of motion by the eye. This starts from the fact that there is an after-image of movement. If you look at a moving stream from a bridge and then turn your attention to the bank of the stream the latter seems to be moving in a direction opposite to that of the stream. This is a negative after-image of movement and its explanation has been attempted by assuming an actual movement on the part of some of the retinal elements. But we have no corroborative evidence of this streaming of the retinal elements, in fact, what we know of the actual structure of the retina tends to contradict this assumption. It is quite improbable that the perception of motion is due to an actual and corresponding movement of certain elements in the retina.



Photograph, taken by Professor Stratton, of the movement of an eye in following the outline of a circle.

For some time it was also stated by some psychologists that there is a special sensation of motion. This was done by the earlier introspective psychologists who used the inner experience of motion, which could not be analyzed further, as the basis for their classification of the senses. The other criteria for a sensation, however, they ignored. They did not stop to analyze the physical stimulus to determine whether or not it was unique or a part of other stimuli. They also neglected to search for or indicate the sense organ which is necessary if there is to be a special sense of movement. Obviously as a special sensation movement fails to meet these requirements.

If we analyze movement as a stimulus we find that it resolves itself into a series of changes in the stimulation of the retina. Are these changes continuous and steady in ordinary vision or are they

seen only in certain progressive stages as in the motion-picture film? In other words, is the stimulation which produces the movement in the motion picture the same or different from that of daily life? We shall have an answer to this in a moment.

The eye is constantly in motion; it is never at rest for more than a few hundredths of a second at a time. Ordinarily we are completely unaware of these constant movements of the eye, but they are present and have been accurately observed and studied in detail in the laboratory. In reading a line of print, for example, the eye does not progress evenly and smoothly, but makes five or six irregular jumps.

Partial blindness characterizes the eye during these periods of their motion. For a time it was thought the eye was completely blind while in motion. It has been proved now that during these periods it is not completely anæsthetic although it senses only a vague, indefinite, hazy blurr at most.

Thus in ordinary vision, although the moving object may be progressing at a uniform rate, the actual retinal stimulation is jerky due to the incessant movement of the eye. Ordinary vision is essentially momentary in character and cross-sections motion in various phases, just as the motion-picture camera photographs progressive phases of the action. In either instance there is no difference between the perception of motion. The motion itself is not seen. What is seen is the change in positions and a blurr which may be looked upon as the sensory index of the change.

The perception of motion, both actual and pictured, is largely a matter of apperception. The movement between the positions actually seen is supplied by the mind from its storehouse of past experiences. The successive pictures shown or scenes perceived

2 1 3 4 5
out of sight they anchored their ships behind a

THIS IS AN ACTUAL RECORD OF THE EYE PAUSES IN READING A LINE OF PRINT BY A FAIRLY EFFICIENT READER. ALL OUR VISION IS CHARACTERIZED BY THESE MOMENTARY FIXATIONS OF THE EYE

serve as a framework along which the mind can fill in the idea of motion. The apparent motion results not alone from the successive stimulation in advancing position, but includes the synthesizing activity of the higher mental processes. The motion picture is no exception to real life in this respect.

And neither is the perception of motion by the eye an exception in the filling-in activities of imagery and expectation. The same filling-in activity of the mind is at work in reading. Only a very few of the letters in any line are really clearly seen, the remainder are supplied by the mind's integration. It is for this reason that the inexperienced proof-reader passes over error after

error; in ordinary perception the eye touches only the high spots, the mind does the rest to round out and complete the awareness of objects and activities.

III

Emphasized again, we find these inner activities at work in the perception of depth, or nearness-farness, in the three dimensional objective world and in the flat two dimensional world of the photo-play.

Our ordinary environment extends not only to the right and left, and up and down, but some objects are also seen close to us while others are far away. This nearness-farness is depth or the third dimension. Just how we perceive depth was one of the first problems to receive the attention of the early experimental psychologists.

The main criteria which we have to assist us in the perception of depth take issue from the fact that our vision is normally binocular. Two eyes make us much more accurate in the perception of the third dimension than would otherwise be the case.

Two brief examples will suffice to indicate the rôle of the second eye. Close one eye and glance around your room. You will notice a loss of the plastic appearance of the furniture. It all looks flat and as if it were in one plane. Try walking around with the same eye closed and find out how inaccurate is your perception of distance.

With one eye still closed attempt to touch your index fingers together about a foot in front of your eyes. See! You missed by from one to three inches, may be more. Try doing the same task now with both eyes open. You will bring your fingers together on the first trial.

There are two prominent ways in which the fact that our vision is normally binocular contributes to our perception of depth. In the first place there is the matter of convergence. When looking at near objects the muscles on the nasal side of the eyeballs contract so that both eyes may be directed toward the objects. With far objects it is the muscles on the temporal side that contract. There is thus a measure of convergence in terms of muscle strain.

More important than convergence is the disparity of the retinal images. Since the eyes are separated by a few inches each one sees a given object at a slightly different angle from the other. You can easily demonstrate this by holding a closed book at arms length in front of you with the back of the book toward you. Look at it first with one eye and then the other. The difference between the two views is marked indeed and in each case the appearance lacks plasticity or depth.

When the same book is seen in the same position by the same eyes simultaneously a different appearance is noted. The two widely disparate views have fused into one which has depth and relief.

This principle of disparity is used in the ordinary stereoscope. The two pictures on the card are taken from a slightly different angle. When viewed through the stereoscope the prismatic lenses bend the rays of light so that the pictures are seen by each eye as if they were of a single object in front of them. Since the pictures have the requisite disparity the resulting appearance is one of a single object in clear relief.

It is not known how it is that these two images which are physiologically different still combine to form a perception that possesses the quality of depth. The important thing, however, is that such is the fact. And in this we again have an example of the integrating activities of the mind.

Motion pictures are flat and lacking in any real quality of depth or any qualities that will give convergence or disparity. Then how is it that nevertheless the observer receives the impression of depth from this representation which is in a single plane? In answering this we shall be initiated still deeper into the almost mysterious processes of integration that are accomplished by the nervous system.

At the outset it is evident that we are certain of our perception of the third dimension in the photoplay. The actors not only walk from right to left but enter and exit through a door at the rear just as they would on a real, three dimensional stage. Then we see the screen troopers gallop away and out of sight into the distant hills. There is no denying the fact that we receive the impression of depth; and there is no denying the fact that as an objective quality depth is lacking in the motion picture.

While the most accurate and predominant factors in the perception of depth are the physiological ones of disparity and convergence, there are still a large number of so-called secondary factors which assist materially in building up these perceptions. It is more fitting that these factors be termed psychological rather than secondary and of late this has come to be the common practice.

What we have long known as perspective is perhaps the most important psychological factor. Distant objects are smaller than near objects; the lines in the visual field converge toward a vanishing point. Perspective is significant in normal, binocular perception of the three dimensional world; it is ultra-significant in the flat world of the motion picture, and even painting for that matter. It is largely this factor which gives apparent depth to flat representations. Artists have long made conscious use of this in their paintings; the Japanese and Chinese still create pictures in which the

perspective is omitted. This results in a characteristic flatness and unreality in appearance.

Again in this perspective we find the integrating activities of the nervous system prominent. Although distant objects cast a smaller image on the retina than near objects the former are still interpreted, not as small people and things, but as of usual size but more remote.

Distant objects are also partially hidden by those nearer the observer. Very distant objects are also seen through a haze and are higher in the field of vision. Shadows are another factor in producing the impression of relief. Without these shadows a photograph would be flat and lack plasticity. Amateur photographers usually overlook this and their photographs are characteristically "flat" in appearance.

The motion pictures utilize all these psychological factors to give the spectators the impression of depth. In addition they take advantage of certain common illusions by having the action take place in the background rather than in the foreground; through this procedure the impression of depth is increased. Sometimes the action in the background is provided by the sea or by a breeze waving the trees. It does not need to be human action to produce the illusion.

The scenic arrangements of the photo-play are selected not alone for their artistic features but, as well, for their depth producing qualities when projected on to the screen. Although this objective screen presentation is flat and without depth, it is possible to take advantage of these psychological factors and thus produce screen dramas as full of depth and plasticity as they are of action and human interest.

Paneled walls in the screen settings are popular with the directors since these enhance the perspective of lines; round tables are discarded in favor of long rectangular ones for the same reason. The rooms used in filming the various scenes are enormously exaggerated as to depth, not primarily to produce an appearance of lavishness, but that the factor of depth may be made to stand out clearer in the projected, flat picture.

What can the scientist predict as to the future development of the technique of the photo-play? In the first place, there are hindrances to any great future development in the elimination of flicker due to the rather large individual differences in the retinal lags. It is necessary for the projection to meet the requirements of the great majority of the spectators, and there will always be some who, through physiological idiosyncrasies, do not receive the continuity of impression and clearness at its maximum. It would not be impossible for those who can afford the luxury to have their

eyes tested for the factors involved in motion picture projection and have a projector built to meet their individual requirements just the same as glasses are ground to order.

Daylight projection is not impossible but will remain a dream for many years. Certain features of the flicker phenomena are a serious handicap in achieving this end. The fusion phenomena takes place with the slowest speed and with the weakest illumination when the general illumination is at its weakest. As the general illumination is increased it becomes necessary for the speed of interruption, or the illumination of the screen, or both to be increased greatly in order to overcome flicker and retain fusion. Mechanical difficulties at present are not such as to make projection of motion with a bright illumination of the theatre out of the question.

Another handicap in the production of fusion is in the fact that apparent motion appears on the screen. This complicates the fusion and in cases of jerky or sudden motion tends to produce flicker of itself. The basis for this is demonstrated in the laboratory where simply moving the hand between the eyes and the revolving sectors which are fusing immediately brings about an occurrence of flicker. One observes this from time to time in the commercial motion picture, especially in the news reviews where football action is portrayed. The government war films of marching soldiers afford a good example of this where fusion takes place from the trunks of the soldiers up, but where flicker is seen in the same pictures where the movements of the legs complicate the projection.

Colored projection will always be hampered not only by the expense and great mechanical difficulties involved, but also by the fact that the lag varies with the colors and it is impossible to get the smoothness that is obtained with black and white. Negative after-images of the colors which are projected with a light stronger than is usual in daily life also contribute to the difficulty of successful colored projection.

The effect of depth will always suffer so long as it is necessary for the photo-play spectators to view the pictures at distances and from angles at which they were not photographed. The maximum effect of depth is obtained when one is at the same position in relation to the scene at which it was photographed. This is one reason why extreme side seats are undesirable. And at the same time no position in the auditorium is perfect in this respect for the various scenes are photographed from different angles and distances.

The photoplay is rapidly becoming an art unto itself and is receiving the merited attention of students of art and aesthetics. Fundamentally, however, it is a triumph of applied science and is only one of the many examples of the rapid progress which has been made in this field in the more recent decades.